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ABSTRACT

The relationship between cognitive activity, achievement, and the number of eye fixations used by a learner in viewing visuals was examined. Past research has shown a positive correlation between learning and number of eye fixations and indicated that both the stimulus materials themselves and the viewer's intelligence level may influence viewing behavior. Complexity and novelty of stimulus have also been previously studied, with contradictory results. The present study used an unobtrusive eye movement measuring system to record the number of eye fixations when subjects were shown either line drawings, shaded drawings, or realistic photographs. Results, based on immediate posttesting, support previous findings that (1) a relationship exists between the number of eye fixations and internal cognitive activity; (2) novelty is an important factor in viewing visuals; and (3) the intelligence level of the subject influences the number of eye fixations. Additional research is needed to determine whether and how different types of visuals influence eye movements. This research study report includes 17 references. (LMM)

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EYE MOVEMENT AS AN INDEX OF LEARNING

by

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Eye Movement As An Index of Learning

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Within the past few years eye movement indicies, i.e., the number of fixations and their average duration, have been used as a measure of cognitive processing. Loftus (1972) found that the number of fixations made by a subject while initially viewing a picture was the best indicator of subsequent picture recognition. Gould's (1973) research indicates that the fixation duration is reflective of cognitive processes while viewing stimuli of varying complexity. Perhaps Wolf (1970) most succinctly states the case of using eye movements as an index of learning:

> Eye movements present an unusual opportunity for finding out the reactions of viewers to a visual stimulus. They give information on where the subject is looking, how long he looks at particular objects and the type of movements he makes...This reaction is different from giving the subject a printed test or asking him in an interview what he has learned from the stimulus. (p. 13)

According to earlier research, there are two factors that may influence the looking behavior of subjects: the stimulus materials themselves and the intelligence level of the viewer. The areas that have received the most attention from researchers are those of complexity and novelty. Faw and Nunnally (1967, 1968), Mackworth and Morandi (1967), Hochberg and Brooks (1978), and Zusne and Michels (1964) found that the more complex stimulus drew more eye fixations than the simpler stimulus materials. However, Wolf (1970) qualified the complexity issue because he found that the more sophisticated stimulus materials attract more eye fixations, but only up to a point. When the stimulus becomes extremely complex, the subject may tend to avoid the stimuli or to fixate centrally.

Just as the complexity issue is clouded with contradictory findings, so are the results of picture recall tests. It was mentioned earlier that Loftus (1972) found that recall is positively related to the number of times a subject fixated a picture. Tversky (1974), however, found different results. In her study, subjects who fixated the stimulus material fewer times had the highest recall on later memory tasks. The two studies did differ in the type of stimulus materials employed: Loftus used photographs and Tversky used simple line drawings.

According to some previous research, it is the viewers' intelligence levels -- not the stimulus materials -- which influence how viewers look at the stimulus material. Anderson (1937), Guba, Wolf, deGroot, Knemeyer, Van Atta, and Light (1964), and Wolf (1970) have all completed research in which a correlation between eye fixations and intelligence was evidenced. It should be emphasized, however, that some of these studies had confounding problems.

The following hypotheses were explored in this study:

- Subjects who have a greater number of eye fixations will have higher scores on the posttest than students who have fewer fixations.

- Subjects who view the stimulus materials composed of shaded line drawings will have more eye fixations than subjects who view either the simple line drawings or the realistic photographic representations.

- Subjects who are in varying categories of intelligence will have different numbers of eye fixations.

The experimental design of the study was the posttest only control-treatment groups but the subjects were not randomly assigned to either of the groups because of geographical limitations. The treatment subjects (N = 46) were students enrolled at Harford Community College, Harford MD which is in close proximity to the Human Engineering Laboratory, Aberdeen Proving Ground, MD where the advanced, unobtrusive oculometer is located which was utilized in the study. The control subjects were all enrolled at Mansfield State College, Mansfield, PA and this is where the investigator is employed.

The treatment subjects were administered the physiology pretest and the mental ability test before they were individually shown one of the treatment conditions, i.e., simple line drawings, shaded drawings, or realistic photographs. Immediately after viewing the treatment slides, the subject was taken to another room and administered the posttest. All tests were administered to the control subjects in the same sequence as the treatment subjects.

As alluded to earlier, the study was conducted at the Human Engineering Laboratory, Aberdeen Proving Ground, Maryland because they maintain an advanced oculometer which has the capability of tracking the eye movements of a subject unobtrusively. For a more complete description of the oculometer, the reader is referred to an article published by Monty (1975).

Four statistical tests were utilized in the study to analyze the data. A **t** test was used to compare the pretest and posttest scores of the treatment and control subjects and there was no difference on the pretest, i.e., $t(89) = 1.64$, $p = .104$, but there was on the posttest, i.e., $t(68) = -12.7$, $p = .001$. To test for any relationship between eye fixations and posttest scores, the Product Moment Coefficient was used. The overall relationship between eye fixations and the posttest score was $r = .2467$, $p = .049$. Three additional Pearson **r**'s were computed for each sequence of 13 slides of the total of 39 slides to determine if the relationship varied during the treatment and they are .1834, $p = .111$; .1948, $p = .097$; and .3040, $p = .020$ respectively.

To determine if eye fixations are influenced by either the type of visuals viewed or the intelligence of the viewer, two-way analysis of variance was employed. The effect of the type of treatment was not significant, $F(2,57) = 1.73$, $p = .192$, but the intelligence level of the subject did influence the average number of fixations and was significant, $F(2,37) = 3.89$, $p = .029$.

Finally, two-way analysis of variance with repeated measures was used to determine if fluctuations in the eye fixation data could skew the data.

Again, it was found that the treatment was not significant $F(2,37) = 1.73$, $p = .191$, but intelligence level was significant $F(2,37) = 3.88$, $p = .030$. In addition, the mean number of fixations did vary throughout the treatment, $F(2,74) = 58.74$, $p = .001$, but neither the interaction of treatment type and slide group, $F(4,74) = .68$, $p = .610$, or intelligence level and slide group, $F(4,74) = .41$, $p = .799$, were significant using the repeated measures test.

Conclusion

The present study supports previous findings that: (1) there is a relationship between the number of eye fixations and internal cognitive activity, (2) novelty is an important factor in viewing visuals, and (3) the intelligence level of the subject influences the number of eye fixations. The study did not give evidence that the level of picture complexity will influence the number of eye fixations.

Discussion

The present study was designed to determine if a relationship exists between cognitive activity, i.e., posttest scores and the number of fixations. Past research has indicated that there is a positive correlation between learning and the number of eye fixations. The present study confirmed this relationship using an unobtrusive eye movement measuring system.

The second objective of the study was to determine if eye movement is a stimulus or a personalogical variable. The present study did provide evidence that it is personalogical: Subjects in the highest category of intelligence had a significantly higher number of fixations than did subjects in the lowest category of intelligence. This finding supports previous research.

The investigator did not find a relationship between the type of visuals viewed and eye movements. This result is similar to Barron's (1980) work because neither study found any evidence that the stimulus materials influenced eye movements. It should be noted, however, that the findings of the present study were both internally consistent and supportive of the research of Loftus (1972, 1976), i.e., no difference in eye movements should be expected because there was no significant difference in learning. Thus, additional research needs to be completed in order to learn whether, and how, different types of visuals influence eye movement. For instance, Fleming (1978) has listed many perception principles which are based on previous research, but not on eye movement studies. It would be interesting to construct visuals which incorporate the principles outlined by Fleming to determine if eye movement research will support the previously reported findings. Since eye movement indices are more item specific than other summary measures such as posttests, the results of the proposed research may enable researchers to refine the principles presented by Fleming through the use of current technology such as the HEL Oculometer. This latter type of information, if available, would be instrumental in providing guidance in the design, development,

and use of visual materials in the learning process because researchers (Baron, 1980; Rayner, 1978; Wolf, 1970; Yarbus, 1967) have concluded eye movements are an objective measure of cognitive activity.

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